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Spatial assessment of growth and instability of livestock products in India

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ABSTRACT

Past studies regarding the growth and instability in production of livestock products have been conducted either for India or the major producing states. Therefore, the present study was conducted to estimate the growth and instability in production of milk, meat and egg, across all the states of India. The study is based on secondary data for a period ranging from 2000-01 to 2019-20. Percentage change, exponential growth function and Cuddy-Della Valle Index were utilized for calculating the relative growth rates, annual growth rates and level of instability. Results revealed that at the country level, India had achieved significant growth alongside low instability in its production of milk, meat and egg. However, large variations in growth rates and per-capita availabilities were detected at the state level. Current production levels of meat and egg were found inadequate in the majority of Indian states. Furthermore, an instability in production of meat and egg was observed in several states. The study recommends an inclusive and thorough execution of various livestock schemes along with timely transfer of credit and other extension services to reduce the inter-state disparities in livestock production. States with high level of instability in production must work on plugging the gap in their backward linkages, while states exhibiting low instability can focus on the processing of these highly perishable commodities.

Keywords: Egg, Growth, Instability, Livestock products, Meat, Milk

Livestock products are potent sources of combating malnutrition, generating employment and earning foreign exchange. Recently, the Government of India has proposed adding milk and egg to its flagship programs of Mid-Day Meal and National Nutrition Mission to alleviate malnutrition in the vulnerable sections of society. Increasing milk, meat and egg production has also been determined in the strategies for doubling the farmers' income.

A key objective of production is to achieve growth in the long run accompanied by minimal volatility. Although India has come a long way from being a net importer of livestock commodities to being their net exporter, their national demand is estimated to outpace their annual production (Saxena *et al.* 2019), leading to a rise in their prices. The rising price of milk has already been identified as a major contributor to food price inflation within the country (Sekhar *et al*. 2017). This elicits threat to the nutritional status of a multitude of Indian households and greatly affects consumers' welfare (Pingali *et al*. 2019).

Furthermore, given the expected population growth and emerging export opportunities, the government has set annual growth targets for milk and egg production at 9.2% and 7%, respectively (National Action Plan). To achieve such high production levels, the growth is required to be inclusive and geographically more diffused. Therefore, this paper attempts to estimate the rates of growth and levels of instability at the state level, to get a lucid picture of the livestock production scenario within the country. The findings will prove useful in identifying the deficient states and formulating state-specific plans of action.

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MATERIALS AND METHODS

Time-series data on milk, meat, and egg production were compiled from government reports such as the Handbook of Statistics on Indian States and Basic Animal Husbandry Statistics. Given the data availability, the study was carried out for a period from 2000-01 to 2019-20.

Growth was investigated in terms of relative as well as compound annual growth. Relative growth rates were worked out as follows.

$$\text{Relative growth (\%)} = \frac{\text{(Production in present year} - \text{Production in base year)}}{\text{(Production in base year)}} \times 100$$

Annual growth rates were worked out by fitting the following exponential function.

$$Y_t = ae^{bt}$$

Where, Y, milk/ meat/ egg production; a, intercept; b, regression coefficient; t, time variable.

Table 1. State-wise surplus or deficit in the per capita availability of milk, meat and egg in India during 2019-20

State	Milk		Meat		Egg	
	Per-capita availability (g/day)	Per-capita surplus/deficit (g/day)	Per-capita availability (kg/annum)	Per-capita surplus/deficit (kg/annum)	Per-capita availability (eggs/annum)	Per-capita surplus/deficit (eggs/annum)
Andhra Pradesh	799	+499	16.24	+5.29	419	+239
Arunachal Pradesh	110	-190	15.14	+4.19	40	-140
Assam	73	-227	1.53	-9.42	15	-165
Bihar	240	-60	3.21	-7.74	23	-157
Chhattisgarh	159	-141	2.29	-8.66	70	-110
Goa	109	-191	4.57	-6.38	26	-154
Gujarat	615	+315	0.48	-10.47	28	-152
Haryana	1118	+818	19.26	+8.31	230	+50
Himachal Pradesh	573	+273	0.68	-10.27	15	-165
Jammu & Kashmir	507	+207	7.07	+3.88	16	-164
Jharkhand	170	-130	1.79	-9.16	19	-161
Karnataka	375	+75	4.62	-6.33	101	-79
Kerala	198	-102	12.87	+1.92	62	-118
Madhya Pradesh	568	+268	1.30	-9.65	29	-151
Maharashtra	269	-31	9.31	-1.64	52	-128
Manipur	79	-221	9.29	-1.66	35	-145
Meghalaya	74	-226	14.12	+3.17	34	-146
Mizoram	54	-246	13.14	+2.19	36	-144
Nagaland	78	-222	14.69	+3.74	18	-162
Odisha	144	-156	4.55	-6.40	53	-127
Punjab	1221	+921	8.28	-2.67	188	+8
Rajasthan	904	+604	2.58	-8.37	35	-145
Sikkim	345	+45	6.00	-4.95	7	-173
Tamil Nadu	316	+16	8.73	-2.22	264	+84
Tripura	136	-164	12.72	+1.77	74	-106
Uttar Pradesh	387	+87	5.17	-5.78	15	-165
Uttarakhand	447	+147	2.21	-8.74	42	-138
West Bengal	165	-135	9.27	-1.68	100	-80
India	406	+106	6.42	-4.53	85	-95

Source: author's calculation. *Note: Telangana has not been included in analysis since it was formed in the year 2014.

Subsequently, compound annual growth rates were worked out using the following formula.

$$CAGR\ (\%) = [(\text{antilog } b) - 1] \times 100$$

To examine the statistical significance of obtained growth rate, student t-test was used. Furthermore, to assess the sufficiency of growth rates, the surplus/deficit in per capita availabilities of milk, meat, and egg were worked out (Table 1). They have been calculated in reference to the ICMR's recommended consumption guidelines of 300 g of milk/day/person, 10.95 kg of meat/person/annum, and 180 eggs/person/annum.

Instability was estimated using the Cuddy Della Valle Index (CDVI) for determining whether the achieved growth was steady or prone to fluctuations. The formula for constructing this index is as follows.

$$CDVI = CV^* \sqrt{(1-R^2)}$$

Where, CV, coefficient of variation (%); and R^2, adjusted coefficient of multiple determination.

The obtained index values were divided into three categories to represent the different levels of instability (Sihmar 2014): $0 < CDVI \leq 15$ (low instability); $15 < CDVI \leq 30$ (medium instability); $CDVI > 30$ (high instability).

RESULTS AND DISCUSSION

Growth in production of livestock products

Growth in milk production: The results depicted in Table 2 reveal that in two decades, India achieved a relative growth of 146% and an annual growth of 4.82% in its milk production. Eight states, namely Bihar, Madhya Pradesh, Rajasthan, Gujarat, Andhra Pradesh, Odisha, Tripura, and Jharkhand, were found exhibiting higher percentage increases in their milk production than the national increase. Six other states, viz. Haryana, Sikkim, Uttar Pradesh, Chhattisgarh, Maharashtra and Himachal Pradesh exhibited increases of more than 100%, but less than the percentage increase at national level. Kerala was the only state found to show a slight decline in its milk production.

In terms of annual growth, the highest rates were recorded in Bihar, Rajasthan and Madhya Pradesh. Four

Table 2. Growth rates in milk production for India and its states during 2000-01 to 2019-20

State	Milk production (thousand tonnes)		Relative growth (%)	CAGR (%)
	2000-01	2019-20		
Andhra Pradesh	5521	15263	176.45	5.11*
Arunachal Pradesh	42	61	45.24	1.00^{NS}
Assam	683	920	34.70	1.43*
Bihar	2489	10480	321.05	7.27*
Chhattisgarh	777	1676	115.70	4.21*
Goa	45	61	35.56	1.20*
Gujarat	5312	15292	187.88	5.58*
Haryana	4850	11735	141.96	4.57*
Himachal Pradesh	761	1531	101.18	3.80*
Jammu and Kashmir	1321	2506	89.70	3.57*
Jharkhand	910	2321	155.05	4.67*
Karnataka	4599	9031	96.37	3.74*
Kerala	2605	2544	-2.34	0.77**
Madhya Pradesh	4761	17109	259.36	6.89*
Maharashtra	5849	12024	105.57	3.90*
Manipur	66	90	36.36	1.18*
Meghalaya	64	88	37.50	1.57*
Mizoram	14	24	71.43	2.95*
Nagaland	51	62	21.57	1.61**
Odisha	876	2370	170.55	5.04*
Punjab	7777	13348	71.63	2.46*
Rajasthan	7455	25573	243.03	6.94*
Sikkim	35	84	140.00	2.66*
Tamil Nadu	4910	8759	78.39	3.19*
Tripura	77	199	158.44	5.05*
Uttar Pradesh	13857	31864	129.95	4.40*
Uttarakhand	1025	1845	80.00	3.12*
West Bengal	3471	5869	69.09	2.78*
India	80607	198440	146.18	4.82*

* and **indicate significant at 1% and 5% levels of significance, while NS indicates not significant at aforementioned levels of significance.

Table 3. Growth rates in meat production for India and its states during 2000-01 to 2019-20

State	Meat production (thousand tonnes)		Relative growth (%)	CAGR (%)
	2000-01	2019-20		
Andhra Pradesh	291.37	850	191.73	4.61*
Arunachal Pradesh	18.4	23	25.00	0.54***
Assam	17.18	53	208.50	5.70*
Bihar	139.78	384	174.72	5.20*
Chhattisgarh	3.06	66	2056.86	20.16*
Goa	0.46	7	1421.74	13.89*
Gujarat	14.2	33	132.39	7.23*
Haryana	8.59	554	6349.36	12.58*
Himachal Pradesh	3.43	5	45.77	1.99*
Jammu and Kashmir	26.29	95	261.35	7.14*
Jharkhand[(a)]	39	67	71.79	2.46*
Karnataka	94.83	305	221.63	6.23*
Kerala	148.11	453	205.85	11.78*
Madhya Pradesh	17.47	107	512.48	14.26*
Maharashtra	210.51	1140	441.54	9.88*
Manipur	20.95	29	38.42	1.58*
Meghalaya	34.32	46	34.03	1.61*
Mizoram	7.64	16	109.42	4.13*
Nagaland	18.73	32	70.85	2.06^{NS}
Odisha	38.39	205	433.99	10.23*
Punjab	5.7	248	4250.88	11.45*
Rajasthan	51.19	200	290.70	8.54*
Tamil Nadu	39.04	663	1598.26	17.42*
Tripura[(b)]	4	51	1175.00	13.71*
Uttar Pradesh	167.98	1166	594.13	14.46*
Uttarakhand	7.32	25	241.53	12.10*
West Bengal	438.26	903	106.04	4.65*
India	1851.43	8599	364.45	9.60*

Note: Sikkim was excluded due to the unavailability of its meat production data for several years in a row.[(a)] denotes production data corresponding to the year 2002-03 and [(b)] denotes production data corresponding to the year 2003-04. *,** and *** indicate significant at 1%, 5% and 10% levels of significance while NS indicates not significant at aforementioned levels of significance.

more states namely, Gujarat, Andhra Pradesh, Tripura and Odisha were found to have higher annual growth than the national annual growth in milk production. In contrast, the lowest annual growth rates were recorded in Kerala, Arunachal Pradesh, Manipur, Goa, Assam, Meghalaya and Nagaland. Amongst these seven states, four fall in the north-eastern part of the country, which has been noted as a milk deficit region by several other studies as well. Lack of raw materials for viable local manufacturing of cattle feed, technical constraints faced by cooperative societies, and prevalence of cattle diseases like haemoprotozoa have been identified as some of the leading causes behind low milk production in these states (Sharma and Rathi 2019, Ghosh *et al.* 2020). This can be observed from Table 1 as well, where Sikkim is the only northeastern state to exhibit a surplus in its per-capita milk availability.

Six other states namely, Bihar, Odisha, Jharkhand, Chhattisgarh, Maharashtra and West Bengal, that recorded annual growths of about 7%, 5%, 4.7%, 4%, 3.9% and 3%, respectively, were also found deficit in their per-capita availabilities. This implies that the growth rates achieved by the aforementioned states need to be further boosted to be in synchronization with their growing populations.

Growth in meat production: From Table 3, it can be seen that in 20 years, India achieved a relative growth of 365% and an annual growth of nearly 10% in its meat production. Nine states namely, Chhattisgarh, Goa, Haryana, Madhya Pradesh, Maharashtra, Odisha, Punjab, Tamil Nadu, and Uttar Pradesh were found exhibiting higher percentage increases in their meat production than the increase at national level. Tremendous growth of more than 1000% was observed in five states, viz. Chhattisgarh, Goa, Haryana, Punjab, and Tamil Nadu.

In terms of annual growth, Chhattisgarh, Haryana, and Punjab recorded growth of more than 20%, while eight

Table 4. Growth rates in egg production for India and its states during 2000-01 to 2019-20

State	Egg production (lakhs)		Relative growth (%)	CAGR (%)
	2000-01	2019-20		
Andhra Pradesh	118000	219275	85.83	1.73**
Arunachal Pradesh	85	605	611.76	3.61*
Assam	5061	5149	1.74	-0.34^{NS}
Bihar	7177	27408	281.89	5.64*
Chhattisgarh	7326	20289	176.95	10.46*
Gujarat	3460	19274	457.05	10.14*
Haryana	10855	66153	509.42	1.50*
Himachal Pradesh	816	1066	30.64	1.73**
Jammu and Kashmir	5689	2216	-61.05	-5.01*
Jharkhand	5500	6928	25.96	1.05^{NS}
Karnataka	19917	66511	233.94	7.72*
Kerala	20344	21845	7.38	3.23*
Madhya Pradesh	7022	23794	238.85	3.94*
Maharashtra	30985	63713	105.63	5.70*
Manipur	695	1082	55.68	2.44*
Meghalaya	874	1102	26.09	1.06*
Mizoram	279	433	55.20	1.93*
Nagaland	553	382	-30.92	-3.91*
Odisha	7297	23814	226.35	5.94*
Punjab	29640	56388	90.24	3.15*
Rajasthan	5715	26962	371.78	6.93*
Sikkim	95	48	-49.47	-3.84*
Tamil Nadu	39294	200216	409.53	9.81*
Tripura	1053	2950	180.15	6.83*
Uttar Pradesh	8116	34049	319.53	9.11*
Uttarakhand	893	4786	435.95	8.07*
West Bengal	26920	97350	261.63	6.92*
India	366323	1143831	212.25	6.01*

Note: Goa was excluded due to discrepancies in its annual egg production data.* and ** indicate significant at 1% and 5% levels of significance, while NS indicates not significant at aforementioned levels of significance.

states namely, Goa, Kerala, Madhya Pradesh, Odisha, Tamil Nadu, Tripura, Uttarakhand, and Uttar Pradesh recorded annual growth in the range of 10% to 20%. The remaining seventeen states reported annual growth of less than 10%. Overall, the growth rates achieved in meat production were observed to be higher than those in milk production. However, despite the increase, from Table 1 it can be seen that, almost two-thirds of the states were lacking in their per-capita meat availabilities. Only nine states, viz. Andhra Pradesh, Arunachal Pradesh, Haryana, Jammu and Kashmir, Meghalaya, Mizoram, Nagaland, Kerala, and Tripura had higher per-capita meat availabilities than the ICMR's recommended consumption guideline. Five of these states are in the northeast region showing that the region's performance is much better in case of meat production as compared to milk.

Thus, it can be concluded that the current production level of meat in the majority of Indian states is insufficient. One of the major reasons for this is meat sector still being largely unorganized within the country (NABARD 2018). A lack of modern abattoirs, inadequate veterinary coverage and low vertical integration between producers and processors affect the sector's overall efficiency and sustainability (Muthukumar *et al.* 2021).

Growth in egg production: The results in Table 4 reveals that between 2000-01 and 2019-20, India achieved a relative growth of 212% and an annual growth of about 6% in its egg production. Thirteen states namely, Chhattisgarh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Odisha, Rajasthan, Tamil Nadu, Telangana, Tripura, Uttarakhand, Uttar Pradesh and West Bengal, recorded annual growth rates of more than 5%. While, ten states namely, Andhra Pradesh, Arunachal Pradesh, Bihar, Himachal Pradesh, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, and Punjab recorded annual growth rates in the range of 1-5%. On the contrary, Assam, Jammu and Kashmir, Nagaland, and Sikkim showed declining annual growth rates.

Similar to meat production, no clear pattern could be drawn between the annual growth rate in production of egg and its per capita availability in a state. Astonishingly, only three states, viz. Himachal Pradesh, Punjab, and Tamil Nadu, exhibiting annual growth rates of about 10%, 3%, and 1.5%, respectively, were found surplus in their per-capita egg availabilities. Rest all the states fell short of the recommended consumption guideline of 180 eggs/person/annum (Table 1). Even annual growth rates higher than 10%, as exhibited by Gujarat and Haryana, were found insufficient in meeting the dietary requirement of eggs in the states. This points toward the considerable gap existing between the current and ideal egg production levels in almost all the states. Despite poultry being one of the fastest growing sectors in the country, the industry is often constrained by price sensitivity of input market and insufficient market linkages (DADF Report 2017, Churchil 2022).

Instability in production of livestock products: The results in Table 5 reveal that during 2000-01 and 2019-20, India as a whole experienced low instability in its milk, meat and egg production. While state-wise, in case of milk production, nineteen states fell under the low instability category, with index values ranging from 2.10 to 14.77. The remaining states displayed medium instability, in the range of 15.20 to 28.26. Pleasantly, no state was found exhibiting high instability in its milk production.

In case of meat production, eleven states were found showing low instability with indices ranging from 1.62 to 13.29. Twelve states fell under the category of medium instability, with indices in the range of 15.23 to 29.86, and four states, viz. Goa, Jammu and Kashmir, Nagaland, and Uttar Pradesh showed high instability. Meanwhile, in case of egg, twelve states showed low instability in their production, with indices ranging from 1.55 to 14.08. Nine states exhibited medium instability, in the range of 16.25 to 26.95, whereas, six states experienced high instability, in the range of 30.64 to 40.47.

In conclusion, the present study reveals that while at

Table 5. Level of instability in the production of milk, meat and egg in India and its states during 2000-01 to 2019-20

Level of instability	Milk production		Meat production		Egg production	
	States	CDVI value	States	CDVI value	States	CDVI value
Low instability	Andhra Pradesh	14.09	Arunachal Pradesh	7.16	Arunachal Pradesh	11.93
	Assam	2.19	Assam	5.15	Assam	4.70
	Bihar	8.62	Bihar	12.19	Chhattisgarh	11.15
	Chhattisgarh	10.59	Himachal Pradesh	13.29	Gujarat	14.08
	Gujarat	6.62	Jharkhand	10.34	Himachal Pradesh	11.12
	Goa	11.08	Karnataka	2.12	Maharashtra	8.97
	Himachal Pradesh	5.79	Kerala	1.62	Manipur	14.01
	Jammu and Kashmir	14.77	Manipur	3.32	Meghalaya	1.55
	Jharkhand	8.37	Meghalaya	4.32	Mizoram	8.81
	Kerala	9.54	Mizoram	10.71	Punjab	12.07
	Maharashtra	6.65	Tripura	7.53	Tamil Nadu	9.55
	Manipur	4.23	India	11.98	Uttarakhand	11.48
	Meghalaya	2.10			India	10.73
	Odisha	7.76				
	Punjab	6.98				
	Tamil Nadu	7.61				
	Uttarakhand	4.32				
	Uttar Pradesh	4.86				
	West Bengal	3.04				
	India	8.43				
Medium instability	Arunachal Pradesh	28.26	Andhra Pradesh	25.65	Andhra Pradesh	18.28
	Haryana	15.20	Chhattisgarh	28.76	Haryana	20.93
	Karnataka	16.75	Gujarat	22.37	Jharkhand	21.33
	Madhya Pradesh	20.74	Haryana	20.24	Karnataka	21.42
	Mizoram	23.29	Madhya Pradesh	27.79	Kerala	23.30
	Nagaland	15.21	Maharashtra	22.64	Odisha	23.73
	Rajasthan	15.85	Odisha	15.23	Tripura	16.25
	Sikkim	19.60	Punjab	24.76	Uttar Pradesh	25.92
	Tripura	15.73	Rajasthan	17.49	West Bengal	26.95
			Tamil Nadu	28.22		
			Uttarakhand	29.86		
			West Bengal	20.21		
High instability			Goa	37.69	Bihar	40.47
			Jammu and Kashmir	44.39	Jammu and Kashmir	30.64
			Nagaland	44.34	Madhya Pradesh	36.67
			Uttar Pradesh	32.57	Nagaland	31.68
					Sikkim	30.82
					Rajasthan	37.78

the national level significant growth and low instability are witnessed in the production of milk, meat and egg, at the state level large variations in growth rates and per-capita availabilities are existing. Overall, the growth rates achieved in meat and egg production are recorded to be higher than those in milk production, however, more states are found deficit in their per-capita availabilities of meat and egg as compared to milk. This indicates that while meat and egg sectors are on the right path, much growth is still required to reach the ideal requirement levels. Thus, it can be inferred that a majority of states despite registering significant increases alongside low/medium instability in their livestock production, are still far from being self-sufficient.

The study recommends that to reduce the inter-state disparities in production of stated livestock products, the governments in identified states in association with related agencies and institutions like NDRI, NBAGR, NABARD, APEDA, animal husbandry departments, veterinary councils, agricultural universities, dairy cooperative societies, KVKs, etc. need to ensure an inclusive and thorough execution of livestock schemes running in their states. Proper dissemination of knowledge and management practices to livestock farmers, along with the timely provision of credit and other required services is equally important. Moreover, the states exhibiting high instability in livestock production need to plug the gap in their backward linkages which primarily include the supply

and prices of inputs, veterinary and extension facilities, and fodder availability. States exhibiting low instability, i.e. states that have achieved stability in their milk, meat and egg production can focus on the processing of these highly perishable commodities to increase shelf life and add value.

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